

IN THE CLAIMS

Please amend the claims as follows.

1. (Previously Presented) A method comprising:

receiving in an Ingrained Sharing Directory Cache (ISDC) an incoming operation request including an associated incoming memory address;

determining if the incoming operation request is an Ingrained Sharing Directory Storage (ISDS) data reply, wherein the ISDS data reply includes an indication of system caches sharing a memory line having the same memory address as the incoming memory address, wherein the indication is extracted from two or more ISDS entries matching the incoming memory address;

completing a pending ISDC entry if the incoming operation request is an ISDS data reply, wherein completing includes locating a pending ISDC operation associated with the ISDS data reply in an ISDC pending request queue;

if the incoming operation request is not an ISDS data reply and if there is an ISDC entry associated with the incoming operation request, performing the incoming operation request; and

if the incoming operation request is not an ISDS data reply and if there is no ISDC entry associated with the incoming operation request, creating an ISDC entry, wherein creating includes:

requesting information associated with the incoming memory address from the ISDS;

evicting another ISDC entry if there is no free ISDC entry, wherein evicting includes:

requesting the ISDS to store the information for the evicted ISDC entry, wherein requesting includes transferring to the ISDS bit-vector information associated with the evicted ISDC entry, wherein the bit-vector information is used by the ISDS to select two or more ISDS cells, wherein each of the two or more ISDS cells maintains a dynamic full map of shared memory lines cached in a given set of one of the system caches and has an ISDS entry to be used to store status information for the evicted ISDC entry; and

designating the evicted ISDC entry to the incoming operation request;

marking the created ISDC entry as pending, wherein pending indicates that the ISDC entry is waiting to receive a data reply from the ISDS; and

storing the incoming operation request into the ISDC pending request queue.

2. (Previously Presented) The method of claim 1, wherein the ISDC entry associated with the incoming memory address indicates whether one or more cached copies of a memory line at the same address as the incoming memory address are in shared or dirty-exclusive state.

3. (Previously Presented) A method comprising:

receiving an Ingrained Sharing Directory Storage (ISDS) request; and

selecting an entry in an ISDS, wherein the ISDS includes a plurality of coherence buffers, wherein each of the coherence buffers maintains a dynamic full map of memory lines cached in a given set in system caches and evicted from an Ingrained Sharing Directory Cache (ISDC), wherein each of the coherence buffers maintains a plurality of cells, wherein each of the cells maintains a dynamic full map of shared lines cached in a given set of a given system cache and evicted from the ISDC, and wherein each of the cells maintains a plurality of entries, each of the entries comprising a memory address of an associated memory line and wherein selecting includes:

selecting one of the plurality of coherence buffers based on a SELECT_CB field of an incoming address of an ISDS request;

selecting one of the cells in the selected coherence buffer based on a SELECT_CELL field of the incoming address of the ISDS request, wherein a value of the SELECT_CELL field is associated with one of the system caches; and

selecting an ISDS entry using a MEMORY_TAG field of the incoming address of the ISDS request.

4. (Canceled)

5. (Currently Amended) The method of claim [[4]] 3, wherein the ISDS request stores the MEMORY_TAG field and a state of the memory line into the one or more of ISDS entries.

6. (Original) The method of claim 3, wherein information about copies of a given memory line resides in only one of the coherence buffers.

7. (Previously Presented) An Ingrained Sharing Directory (ISD) controller apparatus for maintaining coherence of cache lines in a multi-cache system, wherein the ISD controller maintains a dynamic full map directory of local memory lines cached in the system caches and wherein the ISD controller comprises:

- an Ingrained Sharing Directory Cache (ISDC) to receive ISDC requests and to store information about memory lines recently cached in the system caches;

- an Ingrained Sharing Directory Storage (ISDS) to store information about memory lines evicted from an ISDC and information about copies of local memory blocks, wherein the ISDS includes a plurality of coherence buffers, wherein each of the coherence buffers maintains a dynamic full map of memory lines cached in a given set in system caches and evicted from an ISDC, wherein each of the coherence buffers maintains a plurality of cells, wherein each of the cells maintains a dynamic full map of shared lines cached in a given set of a given system cache and evicted from the ISDC, and wherein each of the cells maintains a plurality of entries, each of the entries comprising a memory address of an associated memory line; and

- an ISDC pending request queue to store pending ISDC operations;

- wherein the ISDS selects one of the plurality of coherence buffers based on a SELECT_CB field of an incoming address of an ISDS request;

- wherein the ISDS selects one of the cells in the selected coherence buffer based on a SELECT_CELL field of the incoming address of the ISDS request, wherein a value of the SELECT_CELL field is associated with one of the system caches; and

- wherein the ISDS selects an ISDS entry using a MEMORY_TAG field of the incoming address of the ISDS request.

8. (Original) The apparatus of claim 7 wherein the ISDC set and the ISDS set combined include all copies of memory lines cached at any point in time in the system caches.

9. (Original) The apparatus of claim 7, wherein the each of system caches is a set-associative cache.
10. (Previously Presented) An apparatus comprising:
an Ingrained Sharing Directory Cache (ISDC) to store state information about recent copies of local memory blocks, the ISDC to receive Ingrained Sharing Directory Storage (ISDS) requests and create ISDC entries from information presented by the ISDS, wherein the ISDS includes a plurality of coherence buffers, wherein each of the coherence buffers maintains a dynamic full map of memory lines cached in a given set in system caches and evicted from an ISDC, wherein each of the coherence buffers maintains a plurality of cells, wherein each of the cells maintains a dynamic full map of shared lines cached in a given set of a given system cache and evicted from the ISDC, and wherein each of the cells maintains a plurality of entries, each of the entries comprising a memory address of an associated memory line; and
an ISDC pending request queue to store pending ISDC operations.
11. (Original) The apparatus of claim 10, wherein the state information indicates whether the copy of local memory line is dirty exclusive or shared.
12. (Original) The apparatus of claim 10, wherein the ISDC requests are requests to fetch or modify the state information about the copy of the local memory line.
13. (Previously Presented) A system for maintaining coherence of cache lines in a multi-cache system comprising:
a system interconnect; and
a first number of nodes connected via the system interconnect, wherein each of the nodes includes a local memory unit to store local data, wherein each local memory unit includes a plurality of memory lines and wherein each node includes:
a second number of local set-associative system caches, wherein each of the local caches comprise a third number of cache sets and wherein each of the sets comprise a fourth number of cache lines; and
a local Ingrained Sharing Directory (ISD) controller, wherein the local ISD controller comprises:

an Ingrained Sharing Directory Cache (ISDC) to store state information about the recent copies of the local data;

an Ingrained Sharing Directory Storage (ISDS) to store information evicted from the ISDC, wherein the ISDS includes a fifth number of coherence buffers, wherein each of the coherence buffers contains a sixth number of cells, wherein each of the cells contains a seventh number of ISDS entries and wherein each of the cells maintains a dynamic full map of shared lines cached in a given set of a given system cache throughout the first number of nodes and evicted from the ISDC and wherein an eight number of ISDS entries is equal to the product of the first number of nodes, the second number of local set-associative system caches, the third number of cache sets, and the fourth number of cache lines; and

an ISDC pending request queue to store pending ISDC operations;

wherein the ISDS selects one of the coherence buffers based on a SELECT_CB field of an incoming address of an ISDS request;

wherein the ISDS selects one of the cells in the selected coherence buffer based on a SELECT_CELL field of the incoming address of the ISDS request; and

wherein the ISDS selects an ISDS entry using a MEMORY_TAG field of the incoming address of the ISDS request.

14. (Original) The system of claim 13, wherein the fifth number of coherence buffers is equal to the third number of cache sets.

15. (Original) The system of claim 13, wherein the sixth number of cells is equal to the product of the first number of nodes and the second number of local set-associative system caches.

16. (Original) The system of claim 13, wherein the seventh number of ISDS entries is equal to the fourth number of cache lines.

17. (Previously Presented) The system of claim 13, wherein the memory unit includes random access memory.

18. (Previously Presented) A method comprising:

receiving in an Ingrained Sharing Directory Cache (ISDC) an incoming operation request including an associated incoming memory address;

determining whether a first ISDC entry associated with the incoming memory address is in the ISDC;

if the first ISDC entry is not in the ISDC, creating the first ISDC entry, wherein creating includes:

receiving a data reply associated with the incoming memory address from an Ingrained Sharing Directory Storage (ISDS), wherein the ISDS data reply includes an indication of system caches sharing a memory line having the same memory address as the incoming memory address, wherein the indication is extracted from two or more ISDS entries matching the incoming memory address;

determining if there is a free ISDC entry in the ISDC;

if the free ISDC entry is not in the ISDC, evicting a second ISDC entry, wherein evicting includes:

requesting the ISDS to store the information for the evicted second ISDC entry, wherein requesting includes transferring to the ISDS bit-vector information associated with the evicted ISDC entry, wherein the bit-vector information is used by the ISDS to select two or more ISDS cells, wherein each of the two or more ISDS cells maintains a dynamic full map of shared memory lines cached in a given set of one of the system caches and has an ISDS entry to be used to store status information for the evicted ISDC entry; and

designating the evicted second ISDC entry as the free ISDC entry; and

replacing the free ISDC entry with the first ISDC entry, wherein replacing includes converting the indication of system caches in the ISDS data reply into bit-vector information associated with the first ISDC and storing status information of the two or

more matching ISDS entries into corresponding fields of the first ISDC; and
performing the incoming operation request using the first ISDC entry.

19. (Previously Presented) The method of claim 18 wherein evicting further includes marking the first ISDC entry pending, wherein pending indicates that the ISDC entry is waiting to receive a data reply from the ISDS.

20. (Previously Presented) The method of claim 19 further comprising completing a pending ISDC entry if the incoming operation request type is a data reply, wherein completing includes locating a pending ISDC operation in an ISDC pending request queue associated with the ISDS data reply.

21. (Previously Presented) The method of claim 18, wherein the ISDC entry associated with the incoming memory address indicates whether a system cache copy of a memory line unit is the only copy of the memory line in the system, wherein the memory line is located at the same address as the incoming memory address.

22. (Previously Presented) A method comprising:
receiving an Ingrained Sharing Directory Storage (ISDS) entry request associated with an ISDS entry; and

selecting the ISDS entry from an ISDS, wherein the ISDS includes a first set of coherence buffers, wherein each of the first set of coherence buffers includes:

a second set of coherence buffer cells, wherein each of the second set of coherence buffer cells is associated with one or more of a plurality of system caches; and

a third set of ISDS entries, wherein each of the ISDS entries is adapted to store information about one of a fourth set of system cache copies of local memory lines, and wherein the third set of ISDS entries includes the ISDS entry and wherein selecting includes:

selecting one of the first set of coherence buffers using a local memory line address associated with the ISDS entry request;

selecting one or more of the second set of coherence buffer cells using a cell identifier associated with the ISDS entry request, wherein the cell identifier is associated with one of the plurality of system caches; and

selecting the ISDS entry using a memory tag field to select the ISDS entry.

23. (Canceled)

24. (Previously Presented) The method of claim 22, wherein the ISDS entry request specifies the cell identifier and a request type.

25. (Previously Presented) The method of claim 22, wherein information about copies of one memory line reside in only one of the first set of coherence buffers.

26-34. (Canceled)

35. (Previously Presented) A machine-readable medium that provides instructions, which, when executed by a machine, cause the machine to perform operations comprising:

receiving in an Ingrained Sharing Directory Cache (ISDC) an incoming operation request including an associated incoming memory address;

determining whether a first ISDC entry associated with the incoming memory address is in the ISDC;

if the first ISDC entry is not in the ISDC, creating the first ISDC entry, wherein creating includes:

receiving a data reply associated with the incoming memory address from an Ingrained Sharing Directory Storage (ISDS), wherein the ISDS data reply includes an indication of system caches sharing a memory line having the same memory address as the incoming memory address, wherein the indication is extracted from two or more ISDS entries matching the incoming memory address;

determining if there is a free ISDC entry in the ISDC;

if the free ISDC entry is not in the ISDC, evicting a second ISDC entry, wherein evicting includes:

requesting the ISDS to store the information for the evicted second ISDC entry, wherein requesting includes transferring to the ISDS bit-vector information associated with the evicted ISDC entry, wherein the bit-vector information is used by the ISDS to select two or more ISDS cells, wherein the two or more ISDS cells maintains a dynamic full map of shared memory lines cached in a given set of one of the system caches and has an ISDS entry to be used to store status information for the evicted ISDC entry; and

designating the evicted second ISDC entry as the free ISDC entry; and replacing the free ISDC entry with the first ISDC entry, wherein replacing includes converting the indication of system caches in the ISDS data reply into bit-vector information associated with the first ISDC and storing status information of the two or more matching ISDS entries into corresponding fields of the first ISDC; and performing the incoming operation request using the first ISDC entry.

36. (Previously Presented) The machine-readable medium of claim 35, wherein the evicting further includes marking the first ISDC entry pending, wherein pending indicates that the ISDC entry is waiting to receive a data reply from the ISDS.

37. (Previously Presented) The machine-readable medium of claim 36 further comprising completing a pending ISDC entry if the incoming operation request type is a data reply, wherein completing includes locating a pending ISDC operation in an ISDC pending request queue associated with the ISDS data reply.

38. (Previously Presented) The machine-readable medium of claim 35, wherein the ISDC entry associated with the incoming memory address indicates whether a system cache copy of a memory line unit is the only copy of the memory line in the system, wherein the memory line is located at the same address as the incoming memory address.

39. (Previously Presented) A machine-readable medium that provides instructions, which when executed by a machine, cause the machine to perform operations comprising:

receiving an Ingrained Sharing Directory Storage (ISDS) entry request associated with an ISDS entry; and

selecting the ISDS entry from an ISDS, wherein the ISDS includes a first set of coherence buffers, wherein each of the first set of coherence buffers includes:

a second set of coherence buffer cells, wherein each of the second set of coherence buffer cells is associated with one or more of a plurality of system caches; and

a third set of ISDS entries, wherein each of the ISDS entries is adapted to store information about one of a fourth set of system cache copies of local memory lines, and wherein the third set of ISDS entries includes the ISDS entry and wherein selecting includes:

selecting one of the coherence buffers using a local memory line address associated with the ISDS entry request;

selecting one of the coherence buffer cells using a cell identifier associated with the ISDS entry request, wherein the cell identifier is associated with one of the plurality of system caches; and

selecting the ISDS entry using a memory tag field to select the ISDS entry.

40. (Canceled)

41. (Previously Presented) The machine-readable medium of claim 39, wherein the ISDS entry request specifies the cell identifier and a request type.

42. (Previously Presented) The machine-readable medium of claim 39, wherein information about copies of one memory line reside in only one of the first set of coherence buffers.

43. (Previously Presented) The apparatus of claim 7, wherein the information includes status information indicating whether the copies of local memory lines are dirty-exclusive.

44. (Previously Presented) The apparatus of claim 7, wherein the ISDC requests includes requests to fetch or modify the information about the copy of the local memory line.

45. (Previously Presented) The system of claim 13, wherein the set-associative system caches are selected from a set consisting of 4-way set associative caches, 8-way set associative caches, and 16-way set associative caches.